

Serial No. 09/784,255

Attorney Docket No. 42P4728X

**IN THE CLAIMS:**

Please amend claims 25 and 32, as set forth below.

1           1.       (Previously Amended) A thermal management system for an integrated  
2 circuit die comprising:  
3 a temperature detection element formed directly on the integrated circuit die, the  
4 temperature detection element including at least one temperature sensor having an  
5 output;  
6 a power modulation element formed directly on the integrated circuit die, the power  
7 modulation element to reduce power consumption of the integrated circuit die in  
8 response to the output of the at least one temperature sensor;  
9 a control element formed directly on the integrated circuit die, the control element  
10 including at least one register to provide an enable/disable bit for the thermal  
11 management system; and  
12 a visibility element formed directly on the integrated circuit die, the visibility element to  
13 indicate a status of the output of the at least one temperature sensor.

1           2.       (Previously Amended) The system of claim 1, the at least one temperature  
2 sensor comprising:  
3 a reference voltage source providing a reference voltage;  
4 a programmable voltage source providing a programmable voltage proportional to a  
5 temperature of the integrated circuit die; and  
6 a comparator having one input coupled via a first signal line to the reference voltage  
7 source and another input coupled via a second signal line to the programmable  
8 voltage source, the comparator to provide a signal at the output of the at least one  
9 temperature sensor in response to the programmable voltage substantially  
10 equaling the reference voltage.

1           3.       (Previously Amended) The system of claim 2, further comprising a pulse  
2 dampener coupled to the first signal line, the pulse dampener to at least partially remove  
3 electrical noise from the reference voltage.

Serial No. 09/784,255

Attorney Docket No. 42P4728X

1           4.       (Previously Amended) The system of claim 2, further comprising an  
2 analog filter coupled to the second signal line and the first signal line, the analog filter to  
3 detect voltage spikes present in the reference voltage and to add substantially identical  
4 voltage spikes to the programmable voltage.

1           5.       (Previously Amended) The system of claim 2, further comprising a digital  
2 filter coupled to an output of the comparator, the digital filter including an up-down  
3 counter to count clock pulses, the up-down counter to increment once for each clock  
4 pulse detected when the comparator output is at a first state and to decrement once for  
5 each clock pulse detected when the comparator output is at a second state.

1           6.       (Previously Amended) The system of claim 1, the control element further  
2 including at least one of a register to selectively disengage a specified portion of the  
3 thermal management system, a register to enable the thermal management system in  
4 response to an occurrence of an external event, a register to force the thermal  
5 management system active while overriding a disable bit provided by the at least one  
6 register, and a register to allow external software and hardware to enable the thermal  
7 management system.

1           7.       (Previously Amended) The system of claim 1, the visibility element  
2 including at least one of a register to indicate the status of the temperature sensor output,  
3 a register to provide a sticky bit, a counter to count a number of lost clock cycles  
4 resulting from operation of the thermal management system, and circuitry to generate an  
5 interrupt when the output of the at least one temperature sensor transitions to a different  
6 state.

Serial No. 09/784,255

Attorney Docket No. 42P4728X

1           8.       (Previously Amended) The system of claim 1, the power modulation  
2 element to reduce the power consumption of the integrated circuit die by performing at  
3 least one of lowering a supply voltage to the integrated circuit die, lowering a frequency  
4 of a clock signal provided by internal clock circuitry on the integrated circuit die,  
5 performing clock gating of the clock signal provided by the internal clock circuitry,  
6 performing clock throttling of the clock signal provided by the internal clock circuitry,  
7 selectively blocking clock pulses of the clock signal provided by the internal clock  
8 circuitry, disabling at least one of a plurality of functional units on the integrated circuit  
9 die, limiting instructions sent to at least one of the plurality of functional units on the  
10 integrated circuit die, and changing a behavior of at least one of the plurality of functional  
11 units on the integrated circuit die.

1           9.       (Previously Amended) A microprocessor comprising:  
2 a die having a plurality of functional units formed thereon;  
3 internal clock circuitry formed on the die and coupled to at least one of the plurality of  
4 functional units; and  
5 a thermal management system formed directly on the die, the thermal management  
6 system including  
7           a temperature detection element including at least one temperature sensor  
8           having an output;  
9           a power modulation element to reduce power consumption of at least one  
10           of the functional units in response to the output of the at least one  
11           temperature sensor;  
12           a control element including at least one register to provide an  
13           enable/disable bit for the thermal management system; and  
14           a visibility element to indicate a status of the output of the at least one  
15           temperature sensor.

Serial No. 09/784,255

Attorney Docket No. 42P4728X

1           10.   (Previously Amended) The microprocessor of claim 9, the at least one  
2   temperature sensor comprising:  
3   a reference voltage source providing a reference voltage;  
4   a programmable voltage source providing a programmable voltage proportional to a  
5       temperature of the die; and  
6   a comparator having one input coupled via a first signal line to the reference voltage  
7       source and another input coupled via a second signal line to the programmable  
8       voltage source, the comparator to provide a signal at the output of the at least one  
9       temperature sensor in response to the programmable voltage substantially  
10      equaling the reference voltage.

1           11.   (Previously Amended) The microprocessor of claim 10, further  
2   comprising a pulse dampener coupled to the first signal line, the pulse dampener to at  
3   least partially remove electrical noise from the reference voltage.

1           12.   (Previously Amended) The microprocessor of claim 10, further  
2   comprising an analog filter coupled to the second signal line and the first signal line, the  
3   analog filter to detect voltage spikes present in the reference voltage and to add  
4   substantially identical voltage spikes to the programmable voltage.

1           13.   (Previously Amended) The microprocessor of claim 10, further  
2   comprising a digital filter coupled to an output of the comparator, the digital filter  
3   including an up-down counter to count clock pulses, the up-down counter to increment  
4   once for each clock pulse detected when the comparator output is at a first state and to  
5   decrement once for each clock pulse detected when the comparator output is at a second  
6   state.

Serial No. 09/784,255

Attorney Docket No. 42P4728X

1           14.   (Previously Amended) The microprocessor of claim 9, the control  
2 element further including at least one of a register to selectively disengage a specified  
3 portion of the thermal management system, a register to enable the thermal management  
4 system in response to an occurrence of an external event, a register to force the thermal  
5 management system active while overriding a disable bit provided by the at least one  
6 register, and a register to allow external software and hardware to enable the thermal  
7 management system.

1           15.   (Previously Amended) The microprocessor of claim 9, the visibility  
2 element including at least one of a register to indicate the status of the temperature sensor  
3 output, a register to provide a sticky bit, a counter to count a number of lost clock cycles  
4 resulting from operation of the thermal management system, and circuitry to generate an  
5 interrupt when the output of the at least one temperature sensor transitions to a different  
6 state.

1           16.   (Previously Amended) The microprocessor of claim 9, the power  
2 modulation element to reduce the power consumption of the at least one functional unit  
3 by performing at least one of lowering a supply voltage to the die, lowering a frequency  
4 of a clock signal provided by the internal clock circuitry, performing clock gating of the  
5 clock signal provided by the internal clock circuitry, performing clock throttling of the  
6 clock signal provided by the internal clock circuitry, selectively blocking clock pulses of  
7 the clock signal provided by the internal clock circuitry, disabling at least one of the  
8 plurality of functional units on the die, limiting instructions sent to at least one of the  
9 plurality of functional units on the die, and changing a behavior of at least one of the  
10 plurality of functional units on the die.

Serial No. 09/784,255

Attorney Docket No. 42P4728X

1           17.   (Previously Amended) A computer system comprising:  
2   at least one memory device coupled to a bus; and  
3   at least one microprocessor coupled to the bus, the at least one microprocessor including  
4           a die having a plurality of functional units formed thereon;  
5           internal clock circuitry formed on the die and coupled to at least one of the  
6           plurality of functional units; and  
7           a thermal management system located on the die, the thermal management  
8           system including  
9                a temperature detection element formed directly on the die,  
10               the temperature detection element including at least  
11               one temperature sensor having an output;  
12               a power modulation element formed directly on the die, the  
13               power modulation element to reduce power  
14               consumption of at least one of the functional units  
15               in response to the output of the at least one  
16               temperature sensor;  
17               a control element formed directly on the die, the control  
18               element including at least one register to provide an  
19               enable/disable bit; and  
20               a visibility element formed directly on the die, the visibility  
21               element to indicate a status of the output of the at  
22               least one temperature sensor.

Serial No. 09/784,255

Attorney Docket No. 42P4728X

1           18.   (Previously Amended) The computer system of claim 17, the at least one  
2 temperature sensor comprising:  
3 a reference voltage source providing a reference voltage;  
4 a programmable voltage source providing a programmable voltage proportional to a  
5 temperature of the die; and  
6 a comparator having one input coupled via a first signal line to the reference voltage  
7 source and another input coupled via a second signal line to the programmable  
8 voltage source, the comparator to provide a signal at the output of the at least one  
9 temperature sensor in response to the programmable voltage substantially  
10 equaling the reference voltage.

1           19.   (Previously Amended) The computer system of claim 18, further  
2 comprising a pulse dampener coupled to the first signal line, the pulse dampener to at  
3 least partially remove electrical noise from the reference voltage.

1           20.   (Previously Amended) The computer system of claim 18, further  
2 comprising an analog filter coupled to the second signal line and the first signal line, the  
3 analog filter to detect voltage spikes present in the reference voltage and to add  
4 substantially identical voltage spikes to the programmable voltage.

1           21.   (Previously Amended) The computer system of claim 18, further  
2 comprising a digital filter coupled to an output of the comparator, the digital filter  
3 including an up-down counter to count clock pulses, the up-down counter to increment  
4 once for each clock pulse detected when the comparator output is at a first state and to  
5 decrement once for each clock pulse detected when the comparator output is at a second  
6 state.

Serial No. 09/784,255

Attorney Docket No. 42P4728X

1           22.   (Previously Amended) The computer system of claim 17, the control  
2 element further including at least one of a register to selectively disengage a specified  
3 portion of the thermal management system, a register to enable the thermal management  
4 system in response to an occurrence of an external event, a register to force the thermal  
5 management system active while overriding a disable bit provided by the at least one  
6 register, and a register to allow external software and hardware to enable the thermal  
7 management system.

1           23.   (Previously Amended) The computer system of claim 17, the visibility  
2 element including at least one of a register to indicate the status of the temperature sensor  
3 output, a register to provide a sticky bit, a counter to count a number of lost clock cycles  
4 resulting from operation of the thermal management system, and circuitry to generate an  
5 interrupt when the output of the at least one temperature sensor transitions to a different  
6 state.

1           24.   (Previously Amended) The computer system of claim 17, the power  
2 modulation element to reduce the power consumption of the at least one functional unit  
3 by performing at least one of lowering a supply voltage to the die, lowering a frequency  
4 of a clock signal provided by the internal clock circuitry, performing clock gating of the  
5 clock signal provided by the internal clock circuitry, performing clock throttling of the  
6 clock signal provided by the internal clock circuitry, selectively blocking clock pulses of  
7 the clock signal provided by the internal clock circuitry, disabling at least one of the  
8 plurality of functional units on the die, limiting instructions sent to at least one of the  
9 plurality of functional units on the die, and changing a behavior of at least one of the  
10 plurality of functional units on the die.



Serial No. 09/784,255

Attorney Docket No. 42P4728X

1           25.   (Currently Amended) A method comprising:  
2   providing an enable bit to a register to activate a thermal management system of a die;  
3   measuring a temperature on the die with a sensor of the thermal management system;  
4   providing a first state at an output of the sensor when the temperature is below a trip  
5       point;  
6   providing a second state at the sensor output when the temperature equals or exceeds the  
7       trip point;  
8   in response to the sensor output having the second state, engaging a power reduction  
9       mechanism for a specified time ~~period~~ interval to reduce power consumption of  
10      the die;  
11   polling the sensor output after expiration of the specified time ~~period~~ interval;  
12   engaging the power reduction mechanism for at least another one of the specified time  
13       ~~periods~~ intervals if the sensor output exhibits the second state; and  
14   halting the power reduction mechanism when the sensor output exhibits the first state.

1           26.   (Previously Amended) The method of claim 25, further comprising  
2   engaging the power reduction mechanism to perform at least one of lowering a supply  
3   voltage to the die, lowering a frequency of a clock signal provided by internal clock  
4   circuitry on the die, performing clock gating of the clock signal provided by the internal  
5   clock circuitry, performing clock throttling of the clock signal provided by the internal  
6   clock circuitry, selectively blocking clock pulses of the clock signal provided by the  
7   internal clock circuitry, disabling at least one of a plurality of functional units on the die,  
8   limiting instructions sent to at least one of the plurality of functional units on the die, and  
9   changing a behavior of at least one of the plurality of functional units on the die.

1           27.   (Previously Amended) The method of claim 25, further comprising  
2   providing an enable bit to the register from an external operating system.

Serial No. 09/784,255

Attorney Docket No. 42P4728X

1           31.   (Previously Amended) The method of claim 25, further comprising:  
2    incrementing an up-down counter coupled with the sensor output once for every clock  
3           pulse of the clock signal provided by the internal clock circuitry when the sensor  
4           output exhibits the first state; and  
5    decrementing the up-down counter once for every clock pulse of the clock signal  
6           provided by the internal clock circuitry when the sensor output exhibits the  
7           second state.

1           32.   (Currently Amended) The method of claim 25, further comprising:  
2    defining a plurality of trip temperatures, a highest of the plurality of trip temperatures  
3           corresponding to the trip point;  
4    assigning a plurality of duty cycle values to the plurality of trip temperatures, one duty  
5           cycle value of the plurality of duty cycle values corresponding to at least one of  
6           the plurality of trip temperatures; and  
7    providing a clock signal from ~~the~~ internal clock circuitry on the die, the clock signal  
8           exhibiting the one duty cycle value in response to the temperature substantially  
9           equaling that at least one corresponding trip temperature.

1           33.   (Previously Amended) The method of claim 25, further comprising  
2    counting a number of lost clock cycles resulting from engagement of the power reduction  
3    mechanism.

Serial No. 09/784,255

Attorney Docket No. 42P4728X

1           34.   (Previously Amended) An apparatus comprising:  
2   a temperature detection element, the temperature detection element including at least one  
3       temperature sensor having an output;  
4   a power modulation element, the power modulation element to reduce power  
5       consumption of an integrated circuit die in response to the output of the at least  
6       one temperature sensor;  
7   a visibility element, the visibility element to indicate a status of the output of the at least  
8       one temperature sensor, the visibility element including  
9       a register to indicate the status of the output of the at least one temperature sensor;  
10      a register providing a sticky bit;  
11      a counter to count a number of lost clock cycles resulting from operation of the  
12          apparatus; and  
13      circuitry to generate an interrupt when the output of the at least one temperature  
14          sensor transitions to a different state.

1           35.   (Previously Amended) The apparatus of claim 34, further including a  
2   control element, the control element comprising:  
3   a register to provide an enable/disable bit for the apparatus;  
4   a register to selectively disengage a specified portion of the apparatus;  
5   a register to enable the apparatus in response to an occurrence of an external event;  
6   a register to force the apparatus active while overriding a disable bit provided at the  
7       enable/disable bit; and  
8   a register to allow external software and hardware to enable the apparatus.

Serial No. 09/784,255

Attorney Docket No. 42P4728X

1           36.     (Previously Amended) The system of claim 34, the power modulation  
2     element to reduce the power consumption of the integrated circuit die by performing at  
3     least one of lowering a supply voltage to the integrated circuit die, lowering a frequency  
4     of a clock signal provided by internal clock circuitry on the integrated circuit die,  
5     performing clock gating of the clock signal provided by the internal clock circuitry,  
6     performing clock throttling of the clock signal provided by the internal clock circuitry,  
7     selectively blocking clock pulses of the clock signal provided by the internal clock  
8     circuitry, disabling at least one of a plurality of functional units on the integrated circuit  
9     die, limiting instructions sent to at least one of the plurality of functional units on the  
10    integrated circuit die, and changing a behavior of at least one of the plurality of functional  
11    units on the integrated circuit die.

1           37.     (Previously Amended) A method of forming a thermal management  
2     system for an integrated circuit die comprising:  
3     forming a temperature detection element directly on the die;  
4     forming a power modulation element directly on the die;  
5     forming a control element directly on the die; and  
6     forming a visibility element directly on the die.

1           38.     (Previously Added) The method of claim 37, further comprising  
2     calibrating a temperature sensor associated with the temperature detection element.

1           39.     (Previously Added) The method of claim 37, further comprising forming  
2     at least one functional unit on the die.

1           40.     (Previously Added) The method of claim 39, further comprising forming  
2     circuitry on the die common to the at least one functional unit and at least one of the  
3     temperature detection element, power modulation element, control element, and visibility  
4     element.

Serial No. 09/784,255

Attorney Docket N. 42P4728X

- 1           49.   (Previously Added) The method of claim 25, further comprising
- 2   providing an indication of a status of the sensor output to an external device.